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Rockwell International

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RETARDATION ANALYTICAL MODEL TO EXTEND SERVICE LIFE
MONTHLY TECHNICAL PROGRESS NARRATIVE
MONTH OF AUGUST 1984

Prepared for
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA 35812

CONTRACT NO.

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FORWARD

The purpose of this program is to develop and test a fatigue crack growth model that incorporates crack growth retardation effects and is applicable to the materials characteristics and service environments of high performance LH_2/LO_2 engine systems.

The work is performed by Rocketdyne Division of Rockwell International under the sponsorship of National Aeronautics and Space Administration, Marshall Space Flight Center, Contract NAS 8-35507. J. R. Wooten of Rocketdyne Division, Materials Technology Programs, is Program Manager; Dan Matejczyk of Rocketdyne Materials Engineering and Technology is Project Engineer; Paul M. Munafo is NASA Program Manager.

I. INTRODUCTION

It is experimentally well documented that during fatigue crack growth, load excursions in the form of single tensile overloads or high-low block loading sequences can result in retardation or arrest of crack growth. The current crack growth analyses for SSME structural components are based on repetitions of a single maximum-operating-stress cycle, but do not include any crack growth retardation effects of variations in load amplitude. The purpose of this program is to develop a crack growth retardation model that is applicable to high-performance LH_2/LO_2 engine components, taking into account the severe service environments and the characteristics of the materials selected for service in these applications. This experimental and analytical work on crack growth retardation will enable a more accurate treatment of the crack growth problem and may result in more accurate predictions of the lives of fracture critical components.

During this 24-month program, crack growth retardation models will be developed for three SSME materials: Inconel 718, Haynes 188, and Ti-5Al-2.5Sn (ELI). Initial models will be based on a survey of existing retardation models, with modifications as necessary to take into account the operational environments of high-performance LO_2/LH_2 system components. Crack growth calculations will be performed using selected variable-amplitude load profiles that are attainable under laboratory conditions at appropriate temperatures in an inert environment. The primary temperatures of interest are 1100F for Inconel 718, 1350⁰F for Haynes 188, and -320⁰F for Ti-5Al-2.5Sn (ELI). Crack growth tests will be carried out on the three materials to study the validity of the models. Refinements to the preliminary modeling will be followed by more extensive crack growth testing to obtain further verification of the applicability of the models. Limited high-pressure-hydrogen-environment testing will be performed on Inconel 718 and Haynes 188 for comparison to the inert environment testing.

II. TECHNICAL PROGRESS

An important component of this program is the testing of effects of overloads on subsequent fatigue crack growth for Inconel 718 at 1100°F, for Haynes 188 at 1350°F, and for Ti-5Al-2.5Sn (ELI) at -320°F. During this reporting period, effort under the program has continued to be directed at initiating this testing. Figure 1 depicts the program schedule, which has been updated to reflect the time required to initiate the crack growth rate testing and to obtain baseline and overload data. Figure 2 depicts the detailed schedule for the crack growth testing portion of the program. The schedule calls for completion of baseline constant-amplitude fatigue crack growth rate tests by December 31, 1984, and completion of all testing by August 30, 1985.

During the past month, supplier quotations concerning constant amplitude and overload crack growth testing were evaluated, and the Materials Research and Testing Division of Professional Services Group, Hellertown, Pennsylvania, was selected to carry out the testing.

Cutup of specimen blanks for Inconel 718 and Haynes 188 compact tension specimens is now under way, with testing scheduled to begin September 17, 1984. The Ti-5Al-2.5Sn (ELI) material will follow about one month later.

The testing phase of the program will utilize standard, compact-tension specimens having a width of 2.0 inches and a nominal thickness of 0.5 inches. Some details remain to be resolved concerning the specimen thicknesses, particularly in the case of Haynes 188 at elevated temperature where it may be difficult to maintain plane strain conditions.

All the elevated temperature tests will be conducted in an Inconel tubular vessel enclosed by a resistive tubular furnace. Argon will be purged through the containment vessel to prevent excessive oxidation.

For the testing at room temperature, an O-ring sealed environment chamber will be clamped to each side of the specimens and will be purged with inert gas.

For testing of Ti-5Al-2.5Sn (ELI) at -320°F , the specimen will be surrounded with an insulated vessel supplied with sufficient liquid nitrogen to maintain specimen immersion.

At elevated temperature and at cryogenic temperature, the DC electric potential drop technique will be used to monitor crack length. At room temperature, compliance measurement techniques will be used to monitor crack length, enabling crack closure measurements to be obtained.

III. WORK PLANNED

During the coming month, Inconel 718 and Haynes 188 specimen blank cutting will be completed and blanks will be shipped to Professional Services Group for specimen machining. Ti-5Al-2.5Sn (ELI) test stock will be selected, and specimen blanks will be cut.

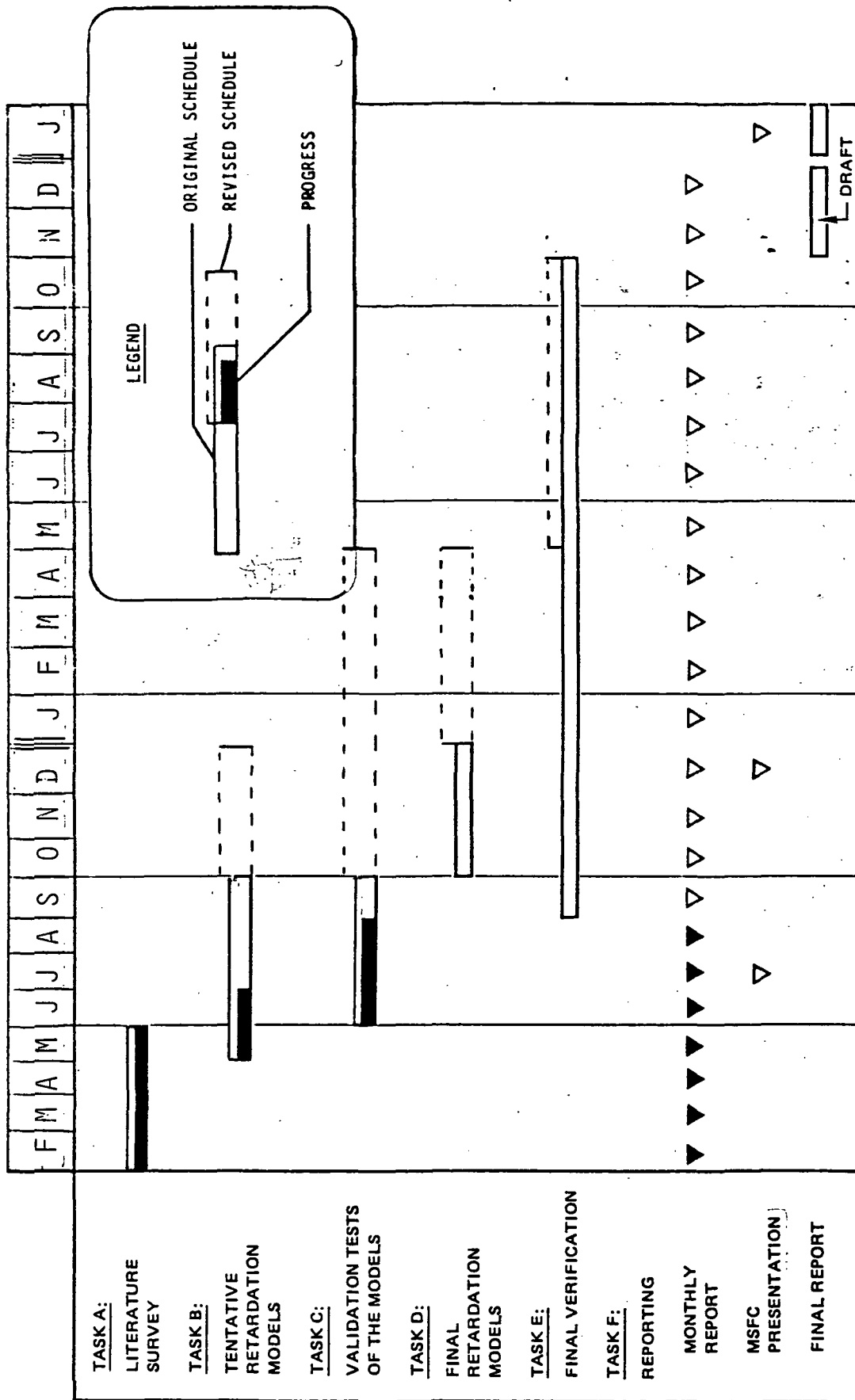


FIGURE 1. PROGRAM SCHEDULE

CRACK GROWTH TESTING SCHEDULE DETAILS

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MONTHLY FINANCIAL REPORT

- (1) Cumulative hours and costs incurred through the month of
August 84 : \$ 23,573
- (2) Contractor final cost estimate: \$ 175,657
- (3) Estimated percentage of physical completion: 13%
- (4) Cumulative cost to physical completion percentage variance
explanation (if any): None

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